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ABSTRACT

A cost analysis of the problem of growing library collections shows that it is more desirable, economically and academically, to establish regional compact shelving facilities for infrequently used library materials than to discard the materials. This report develops and applies a cost model--based on the Palmour Cost Model--which examines the economic aspects of compact shelving and weeding in greater detail. The findings of cost analysis support the conclusions of prior analyses--there is a body of library material, defined by its average frequency of circulation, for which compact shelving facilities are the least expensive housing alternative. This report provides a description of the cost model and its parameters, as well as criteria for relegation and weeding. Appendices detail the methodology of the study. (Author/RAA)

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AN ECONOMIC CRITERION FOR HOUSING AND DISPOSING OF LIBRARY MATERIALS, BASED ON FREQUENCY OF CIRCULATION

by

Gary S. Lawrence
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Research Report RR-79-2
September 24, 1979

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EXECUTIVE SUMMARY

1. *In addressing the problem of housing its growing library collections, the University of California has shown that it is more desirable, both academically and economically, to establish regional compact shelving facilities for infrequently-used library material than to discard the material. This report develops and applies a cost model which examines the economic aspects of compact shelving and weeding in greater detail. The findings of the cost analysis support the conclusions of prior analyses: there is a body of library material, defined by its average frequency of circulation, for which compact shelving facilities are the least expensive housing alternative.*

2. *The cost model developed here is a modification of the model created by Palmour, et al., to examine the cost of subscribing to periodical publications. Both the Palmour model and our modified model attempt to account for the relevant costs associated with the circulation of a volume: direct transaction costs; annual housing costs; and for relegation and weeding, the cost to identify and process volumes to be relocated or weeded. Unlike Palmour, we do not include the costs of acquiring the materials; for relegation and weeding decisions, the materials must have been acquired in the past, and the acquisition expenditures are considered "sunk costs." We augment Palmour's model by including a specific estimate of the "cost" to users of the delays imposed by retrieving materials from regional compact shelving or securing them from other libraries through interlibrary borrowing.*

3. *Most of the cost data needed to implement this model for the University of California libraries is not available at present. Using data drawn from University budget and planning documents and cost figures reported in studies made outside the University to estimate the relevant costs, the cost model indicates that:*

   In campus libraries, the average cost per circulation is **$0.60** *for volumes which circulate once per year; for volumes which circulate once every ten years, the cost per circulation is* **$3.51**; *for volumes which circulate once every forty years, the cost is* **$13.22** *per circulation.*

   In regional compact shelving facilities, the average cost per circulation is **$1.76** *for volumes charged out once per year,* **$3.53** *for volumes requested once in ten years, and* **$9.43** *for volumes which circulate only once in forty years.*

   Using interlibrary borrowing, it costs **$5.19** *per circulation to provide a volume which is demanded once per year,* **$6.03** *for a volume which circulates once in ten years, and* **$8.83** *for a volume which is needed once every forty years.*

4. *On the basis of the cost estimates used in this report, the following economic criteria for relegation and weeding are derived:*

   When there is no compact shelving facility, *items which are circulated once or more in 21 years should be retained on campus; when the circulation rate is less than once in 21 years, it is less expensive to discard the volume and rely on interlibrary borrowing to meet demand.*

   When there is a compact shelving facility, *items which are circulated once or more in ten years should be retained on campus. Volumes with circulation rates between once in ten years and once in 34 years are more economically placed in compact shelving. For volumes with circulation rates lower than once in 34 years, it is less expensive to dispose of them or place them in national repositories, and satisfy demand for them through interlibrary borrowing.*

5. *The economic analysis reported here does not account for a number of non-economic factors which must be given consideration in the development of relegation and weeding programs. The most important consideration is the risk that, if a library chooses to dispose of a volume, a copy may not be available from another library when needed. The report notes that this risk may be avoided by placing infrequently-used materials in a national depository (like the Center for Research Libraries), rather than disposing of them entirely.*

AN ECONOMIC CRITERION FOR HOUSING AND DISPOSING OF LIBRARY MATERIALS, BASED ON FREQUENCY OF CIRCULATION

INTRODUCTION

Housing the Collections of the University of California Libraries

In 1977, the University of California administration estimated that it would cost over $89 million to build new libraries to house the University's growing collection through 1988.[1] It has been evident since the early 1970's that the State of California was unwilling to appropriate these sums. From the University's viewpoint, the obvious alternative to construction of new campus libraries, disposing of the books that cannot fit in available space, was unacceptable: it would be necessary to weed almost 6 million volumes by 1988, and there are few who believe that the University has 6 million "worthless" books to throw out.

The University has therefore chosen to follow a middle road, by establishing two regional compact shelving facilities for library materials that are infrequently circulated. The combination of low-cost construction and high book-storage densities means that the regional facilities can save almost $35 million when compared to the construction of new campus libraries (*Plan for Development*, p. 180). At the same time, the valuable bibliographic resources of the University will be retained and made available to scholars, students and the general public. Adverse effects on the teaching and research programs of the University are minimized, because only infrequently-circulated library materials will be placed in the regional facilities.

Although the general policy creating the regional facilities is clearly established, detailed planning is continuing. Because the problem which gave rise to the regional compact shelving policy was primarily an economic one, we have developed an economic analysis to help resolve some of the remaining issues. The analysis reported here uses a modified version of an existing economic model to clarify some of the consequences of the choice to relegate a particular volume to regional compact shelving, or to dispose of it and rely on borrowing from other libraries to provide a copy of the book when needed. We believe that the findings of this analysis provide reliable estimates of an economic criterion that can be of assistance in selecting materials for relegation or weeding, and estimating the quantities of library materials that should be retained on campus, relegated or weeded, or estimating the total costs of relegation or weeding programs.

Cost Models for Analysis of Alternative Modes of Housing the Collection

In 1968, Westat, Inc. developed a rigorous cost-comparison model to address a problem similar to that faced by the University.[2] The 1968 model was revised and updated in a study conducted by Palmour in 1977.[3] In these studies, the particular problem addressed was the choice to continue

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1. University of California, Office of the Executive Director of Library Planning, *The University of California Libraries: A Plan for Development*, July 1977, p. 161. This document is referred to hereafter as the *Plan for Development*.

2. G. Williams, E. C. Bryant, R. R. V. Wiederkehr, V. E. Palmour, and C. J. Siehler, *Library Cost Models: Owning Versus Borrowing Serial Publications*, Chicago, Illinois, The Center for Research Libraries, 1968.

3. Vernon E. Palmour, Marcia C. Bellassai and Robert R. V. Wiederkehr, *Costs of Owning, Borrowing, and Disposing of Periodical Publications*, Arlington, Virginia, Center for Naval Analyses, October 1977.

subscribing to a periodical, or to cancel the subscription and rely on borrowing from other libraries to satisfy demand for the title. The Palmour report (page 1) described the problem in this way:

> *User needs for periodicals are satisfied in one of two ways by a library or information center: the library either maintains the publication in its own collection, or it borrows requested items from other libraries. Both cost money. To maintain a periodical in its own collection, the library must select, order, process, store and make the publication available. For a requested item in a publication not in its own collection, there is the staff cost to locate and borrow the item; and in many cases, a photocopy charge. The cost to satisfy a request by borrowing is roughly the same each time, whereas the average cost per circulation of a publication acquired for the library collection is a function of how frequently it is circulated. Consequently, for any given periodical title there is some frequency of use at which it becomes cheaper for a library to acquire the publication than to borrow it to satisfy patron demand.*

The problem under investigation in this report is somewhat different than that defined by Palmour, but the underlying logic is the same. To paraphrase the last sentence of the foregoing quotation, for any given volume in the University collection, there is some frequency of circulation at which it becomes cheaper *not* to house the volume in a campus library building.

Objective of the Analysis

The goal of this report is to define that frequency of circulation for a volume in the University collection at which it is no longer economical to continue housing it within a campus library. Specifically, we will apply the Palmour model to available cost and circulation data to estimate (1) the frequency of circulation at which it is economically desirable to transfer an item to compact shelving, and (2) the circulation frequencies at which it is desirable to discard (or transfer to a national repository) an item from (a) the campus collection and (b) the compact shelving collection.

Limitations of the Analysis

The results of economic modelling can be no better than the data used in the model. Cost data used in this report are drawn from available University documents and reports of studies made in other libraries, and could undoubtedly be refined with further research. Later in the report, we will discuss the impact that uncertainty about costs might have on the findings. The most important shortcoming of the data used here relates to the fact that the cost model relies on knowledge about the rates of use of library materials. Ideally, the model should include all forms of use of material, including uses at tables and shelves within the library. Unfortunately, few (if any) libraries have information on the incidence of in-library use of their collections. The problem of "unrecorded use" of libraries is presently under investigation by this office, but for the present, available data compels us to use costs derived only from circulated use, and our findings should be interpreted accordingly. Fortunately, the cost model is perfectly adaptable to an expanded definition of "use" when the requisite data on unrecorded use become available.

More important is the fact that an economic analysis cannot hope to reflect a number of "non-economic" issues with accuracy. Three such issues are prominent in the area of relegation and weeding. First, the fact that materials are no longer in the campus collection may have an effect on user demand for them, even though they may still be "available" at regional facilities or through interlibrary borrowing. Although this problem is being investigated, there is little we can learn about it until we have had a period of experience with regional compact shelving. We have attempted to reflect one aspect of the problem in our cost estimates (by including an estimate of the "cost" to users of the inconvenience of waiting for materials delivered from regional facilities or through interlibrary borrowing), but it should be understood that our results do not fully account for the possible effect on library users of remote housing of library material.

Second, it must be realized that, even when weeding is "economically justified," the disposal of a book may be indefensible on other grounds. When we speak here of weeding and reliance on interlibrary borrowing, we must assume that a copy of the weeded item will be available in some other library when needed. This assumption is not necessarily warranted. At the conclusion of the paper, we shall discuss a form of "insurance policy" against this eventuality. More generally, though, we recognize that

the libraries of the University of California, as major resources for the nation's researchers, bear a responsibility to help ensure that the body of recorded knowledge is preserved. This responsibility is unequivocally important, and just as unequivocally cannot be adequately reflected in the present analysis.

Third, we emphasize that the cost model treats each volume in the library as an independent entity for the purpose of relegation or weeding choices. The limitation of this assumption is evident when we consider the hypothetical case of a 40-volume set of a journal, in which a few scattered volumes are used frequently, but the remainder meet the economic criterion for relegation to compact shelving. Breaking up the journal set through an inflexible application of the economic criterion could be an injudicious decision. The example illustrates the point that an economic criterion is not the only factor to be taken into account in the relegation process. Though the model presented here can clarify the cost factors in relegation and weeding programs, the use of the model cannot substitute for adequate consideration of the non-economic criteria involved in relegation decisions.

THE COST MODEL

The general cost model presented below is derived directly from the model developed by Palmour. Because the present formulation deals with individual volumes (both monographs and periodicals), rather than runs of periodical titles, it is considerably simpler than the model developed for Palmour's periodical study. We have also transformed the model into a linear form that can be used without reliance on a computer. The derivation of the model is explained in detail in Appendix A.

Specifically, the general cost model is:

$$U_t = \frac{C_u r_t}{t} + \frac{C_w + C_v r_t}{t} Y \qquad (1)$$

where:

- U_t = The total cost per circulation, expressed as a present value (see Appendix D, "Discounting, Present Value and Inflation"), when capital costs are amortized over planning period t.
- Y = the expected average number of years between circulations.
- r_t = the net present value factor for a discount rate r over planning period t ($r_t = \sum_{n=1}^{t-1} \frac{1}{1+r^n} = \frac{(1+r)^{t-1}-1}{r(1+r)^{t-1}}$, by a standard formula).
- C_v = the annual cost of housing the volume.
- C_w = the one-time cost to select the volume for weeding or relegation to compact shelving.
- C_u = the direct cost per circulation.

To clarify the application of the general model, we shall discuss it separately for the three options of retention on campus, relegation to compact shelving, and removal from the collection.

Campus Retention

The annual cost of housing a volume on campus (designated as C_v^c) includes the annual equivalent cost of the space and equipment (shelving, etc.) required to house the volume, plus the volume's share of maintenance, utilities, and other recurring annual costs associated with having the volume available on the shelf. Since no "selection" is required, the cost of selection, C_w^c, is zero. The cost of each circulation of the item, C_u^c, includes all costs that can be associated with the circulation of the book, including the book's "share" of reshelving and stack maintenance costs. The circulation rate,

Y, is a variable: for a volume circulated once in 10 years, for instance, the value of Y is 10. The present value factor, r_t, depends on the particular discount rate and planning period used in the analysis. The cost per circulation for a volume which is retained on campus and circulated once every ten years is:

$$U_t^c = \frac{C_u^c r_t}{t} + \frac{0 + C_v^c r_t}{t} \quad (10) \qquad (2)$$

Similarly, for a book circulated once every two years, the cost per circulation is:

$$U_t^c = \frac{C_u^c r_t}{t} + \frac{0 + C_v^c r_t}{t} \quad (2) \qquad (3)$$

Relegation to Regional Compact Shelving Facilities

The cost of housing in regional compact shelving, C_v^{cs}, will be less than C_v^c, due to greater book compaction, lower construction costs, and the like. The cost of each circulation from compact shelving, C_u^{cs}, is likely to be much greater than C_u^c, since the costs of communication and transportation must be added to the usual costs associated with charging the book out to a user, and ideally some estimate of the cost of delay and foregone circulation should be included. The cost of selecting the item for compact shelving, C_w^{cs}, includes the costs associated with identifying the volumes to be sent to compact shelving, the revision of bibliographic records, transportation and initial shelving.

Removal from the Collection

A volume which is removed from the collection ("weeded") incurs no future housing costs ($C_v^w=0$). Selection costs, C_w^w, will be incurred. The cost of circulation, C_u^w, includes direct staff costs for locating and ordering a copy of the volume from another library, any charges levied by the lending library, and some estimate of the costs of delay and foregone uses.

DERIVATION OF COST PARAMETERS

Most of the cost data needed to implement this model for the University of California libraries is not available at present. Estimates of the relevant costs have been developed using data drawn from University budget and planning documents and cost figures reported in studies made outside the University. Appendix C describes the derivation of these costs and includes an analysis of the model's sensitivity to varying cost estimates. Costs used here and in Appendix C are expressed in 1978 dollars.

Discount Rate and Planning Period

To determine the value of r_t, the cost model requires that r, the interest rate, and t, the planning period, be specified. Several values for the interest rate are defensible in theory, but in practice the rate for AAA corporate bonds is most frequently used. This rate has been fluctuating around 8 percent, and for simplicity $r = .08$ will be used throughout this analysis. The value of t is the "useful life" of the object in question, in this case the library or compact shelving facility. We have used a period of 40 years, which is a frequently-used depreciation period for non-residential buildings.

Campus Retention

The annual cost of housing material, C_v^c, has two components: the annualized capital cost of construction and equipment, and the annual recurring cost of maintaining the facility. The average cost per assignable square foot (asf) to construct and equip a campus library in California in 1978 is $126.60.[4] At 0.08 asf per volume, the density standard used in the *Plan for Development* (p. 158), the cost is $10.13 per volume. The annualized cost of a $10.13 capital expenditure over 40 years at 8 percent is $0.85 per year.[5] The annual cost of maintenance must be added. Current estimates for the maintenance of compact shelving facilities have been made (see the following section). On the assumption that the cost of maintenance on campus is roughly comparable, we adopt the regional facility estimate of $0.24 per volume per year. C_v^c is then $0.85 + $0.24, or $1.09 per year.

The cost of each circulation, C_u^c, includes record-keeping, charging and discharging a volume, and reshelving it. This cost is estimated using the 1978/79 Reference/Circulation staff budget of $17,399,000. Following a common convention, one-half of this amount is attributed to circulation operations. Because 1978/79 circulation statistics are not yet available, total circulation was estimated using the assumption that circulation rates grow at the same pace as collection size. From available circulation data for earlier years, 1978/79 circulation is estimated to be 9,439,646 transactions. The average cost in 1978/79 dollars is therefore $0.92 per circulation.

Relegation to Regional Compact Shelving Facilities

The housing cost for remote compact shelving, C_v^{cs}, has two components comparable to those of on-campus housing: the annualized capital cost of building and equipping the facility, and the annual recurring maintenance cost.

The December 1978 Capital Improvement Plan[6] places the cost of constructing and equipping two 3-million volume facilities at $13,956,000, or $2.33 per volume. Annualized over 40 years at 8 percent, this amount is $0.20 per year. Maintenance costs have been developed in detail for the planned compact shelving facilities. Including utilities, the cost is $0.24 per volume per year.[7] C_v^{cs} is then $0.20 + $0.24, or $0.44 per volume per year.

The cost of selection, C_w^{cs}, includes identification, transportation, shelving, and record changing. The cost of selection depends on the method used to identify the volumes, especially on the amount of staff and faculty involvement. The *Plan for Development* provides an estimate of the cost of review for weeding at $0.70 per volume *considered* for discard (p. 169). In a survey of large North American

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4. University of California, "Project Planning Guide: Northern Regional Compact Shelving Facility," December 1978, p. 4.

5. The annual value of the initial capital expenditure is calculated using the standard formula:

$$A = P\left\{\frac{i}{(1+i)^n-1} + i\right\}$$

where:

i= interest rate per period.

n= number of periods.

P= the present sum of money, or initial investment.

A= the end-of-period payment in a uniform series for *n* periods, the entire series equivalent to *P* at interest *i*.

6. University of California, *1979-80 Budget for Current Operations and for Capital Improvements and 1979-82 Capital Improvement Program,* Systemwide Administration, September 1978 (Draft for Discussion).

7. Memorandum, Donald D. Thompson to Stephen R. Salmon, Office of the Assistant Vice President--Library Plans and Policies, University of California, May 18, 1978.

libraries, selection costs were "as high as $2.00 per volume selected."[8] Because the decision to send a book to compact shelving is a reversible one, i.e., the volume can always be returned to the campus collection, we may assume that an inexpensive selection procedure will be acceptable, and use the lower figure of $0.70 per volume *examined.* If we assume that 90 per cent of the books examined are selected for compact shelving, the cost is $0.78 per volume *selected.* The *Plan for Development* (p. 175) also provides a record changing cost of $1.00 per volume, presuming an automated system, for a total of $1.78. In 1978 dollars, this amount is $1.93. Book transportation and initial shelving may add $0.70 (see Appendix C), for a total of $2.63 per volume.

The unit cost of circulation from compact shelving, C_u^{cs}, includes retrieval, transportation, communication, and reshelving. These are all costs incurred by the library. An additional cost is borne by the patron--the cost of the time delay inherent in retrieving materials from an off-campus facility.

Data published by Trueswell and Turner[9] on the distribution of circulation rates in academic libraries indicate that about five per cent of the compact shelving collection could be expected to circulate in a single year. If, as proposed in the *Plan for Development,* volumes that have previously circulated less frequently than once in ten years are housed in compact shelving facilities, the Trueswell and Turner distribution implies an average circulation rate of about 4.7 per cent of the compact shelving collection per year. For facilities containing 5,758,000 volumes (*Plan for Development,* p. 172), this would result in 268,670 annual circulations. Based on the annual staff budget for the regional facilities, presented in Chapter 10 of the *Plan for Development,* the average direct cost per circulation of an item is $1.66, in 1978 dollars.[10] To this we add the cost of round trip transportation (estimated at $1.50 per circulation--see Appendix C), and the cost to users of a two-day delay in delivery from the compact shelving facility ($2.12, from Appendix B), to arrive at the total direct cost of a single circulation, C_u^{cs}=$5.28 per transaction.

Removal from the Collection

The cost of weeding, C_w^w, is analogous to the selection of volumes for compact shelving, and includes review, record changing, and disposing of the volumes. We assume that a campus would adopt the most rigorous feasible review procedures for an irreversible decision to discard a volume. The highest reasonable figure in the literature (Piternik, 1974) of $2.00 per volume *selected* seems justified. Again the cost of changing library records, at $1.00 per volume, is added. Converted to 1978 dollars, the total is $3.73 per volume.

The cost of circulation, C_u^w, includes costs incurred by both the borrowing and lending libraries. Palmour's data on the cost to the borrowing library of an interlibrary lending (ILL) transaction suggests a figure of $7.20 per circulation (Palmour, p.46). Lending libraries may "recover" their costs by charging for ILL. Palmour uses values of $0, $3, and $8. For estimation purposes, we have assumed that the "external" cost of ILL is $3.00 per volume, for a total of $10.20, or $11.04 in 1978. Using the procedures for estimating delays detailed in Appendix B, and assuming a two-week delay on ILL transactions, the cost of delay is $6.12. Thus, the total cost of a circulation, C_u^w, is $17.16.

Summary

Table 1 summarizes our best estimates of the cost parameters for the preliminary analysis of the cost of retention, compact shelving and disposal of library materials as a function of the frequency of circulation. The results of the "best estimate" analysis are presented in the next section. In Appendix C we identify the most uncertain cost elements and present an analysis of the sensitivity of these

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8. George Piternik, *Book Storage in Academic Libraries: A Report Submitted to the Council on Library Resources,* University of British Columbia, School of Librarianship, 1974, p. 7.

9. Richard W. Trueswell and Stephen J. Turner, "Analytic Methods for Monograph Stack Thinning in Libraries," paper presented at the ORSA/TIMS meeting, November 3-6, 1976, Miami, Florida.

10. This estimate also includes provision for supplies and expenses to support the operations of the facilities' staff.

findings to assumptions about the cost parameters.

TABLE 1
Summary of Estimated Cost Parameters:
Campus Housing, Compact Shelving, and Weeding

Alternative	Annual Cost of Housing (C_v)	Cost of Selection (C_w)	Cost of Circulation (C_u)
Retention on Campus	$1.09	$0	$0.92
Compact Shelving	$0.44	$2.63	$5.28
Disposal and Interlibrary Borrowing	$0	$3.73	$17.16

RESULTS OF THE COST ANALYSIS

Because the cost model (Equation 1) is linear with respect to Y, the average number of years between circulations, we can easily calculate a specific cost equation for each mode of housing. When r=.08 and t=40 (page 4, above), the value of r_t is 11.88 (from the formula on page 5, above). Substituting the values of t and r_t in the cost model yields the equation:

$$U_t = \frac{11.88\ C_u}{40} + \frac{C_w + 11.88\ C_v}{40}\ Y \qquad (4)$$

Cost per Circulation for Materials Retained on Campus

The cost per circulation for materials retained on campus is:

$$U_t^c = \frac{11.88(.92)}{40} + \frac{0 + 11.88(1.09)}{40}\ Y \qquad (5a)$$

$$= .2732 + .3237\ Y \qquad (5b)$$

For materials circulated once per year (Y=1), the cost per circulation is $0.60; for volumes circulated once in 40 years (Y=40), the cost per circulation is $13.22.

Cost per Circulation for Materials Relegated to Compact Shelving

The cost per circulation for materials relegated to compact shelving is:

$$U_t^{cs} = \frac{11.88(5.28)}{40} + \frac{2.63 + 11.88(.44)}{40}\ Y \qquad (6a)$$

$$= 1.5682 + .1964\ Y \qquad (6b)$$

For materials circulated once per year, the cost per circulation is $1.76. For volumes circulated once in forty years, cost per circulation is $9.42.

Cost per Circulation for Materials Discarded from the Collection

The cost per circulation for materials removed from the collection, where circulation is provided through interlibrary borrowing, is:

$$U_i'' = \frac{11.88(17.16)}{40} + \frac{3.73 + 11.88(0)}{40} Y \tag{7a}$$

$$= 5.0965 + .0933\ Y \tag{7b}$$

For materials circulated once per year, the cost per circulation is $5.19. For materials circulated once in forty years, the cost per circulation is $8.83.

The cost per circulation for circulation rates from once per year to once in forty years is presented in Table 2 and Figure 1.

"Crossover Points" for Compact Shelving and Disposal

Figure 1 indicates the points at which the cost per circulation for each option crosses the cost function of the other options. The cost function for campus housing, for instance, crosses the cost function for compact shelving at about $Y=10$; that is, when the circulation rate is higher than one circulation in ten years ($Y<10$), the cost per circulation is less for campus housing than for the compact shelving option. When the circulation rate is less than one circulation in ten years ($Y>10$), the cost per circulation from compact shelving is less than with the campus option. Figure 1 indicates, then, that on a cost-per-circulation basis:

> *When there is no compact shelving facility,* items which are circulated once or more in 21 years should be retained on campus; when the circulation rate is less than once in 21 years, it is less expensive to discard the volume and rely on interlibrary borrowing to meet demand.
>
> *When there is a compact shelving facility,* items which are circulated once or more in ten years should be retained on campus. Volumes with circulation rates between once in ten years and once in 34 years are more economically placed in compact shelving. For volumes with circulation rates lower than once in 34 years, it is less expensive to dispose of them or place them in national repositories, and satisfy demand for them through interlibrary borrowing.

The circulation rates at which the cost functions cross are referred to here as "crossover points." From Figure 1, the approximate "best estimate" crossover points are (1) from campus housing to disposal (no compact shelving facility), one circulation in 21 years ($Y=21$); (2) from campus housing to compact shelving, one circulation in ten years ($Y=10$); (3) from compact shelving to disposal, one circulation in 34 years ($Y=34$). Precise crossover points can be calculated from the cost functions presented above, by setting the functional equations equal to each other and solving for Y. To find the campus-to-disposal crossover point, for instance, we set the campus cost function equal to the weeding cost function:

$$\begin{aligned} .2732 + .3237\ Y &= 5.0965 + .0933\ Y \\ (.3237 - .0933)\ Y &= 5.0965 - .2732 \\ .2304\ Y &= 4.8233 \\ Y &= 20.9345 \end{aligned} \tag{8}$$

The precise crossover points resulting from these calculations are presented in Table 3.

TABLE 2
Estimated Present Value Cost per Circulation for Three Housing Options

Average Years Between Circulations (Y)	PRESENT VALUE COST PER CIRCULATION		
	Campus Library	Compact Shelving	Interlibrary Borrowing
1	.60	1.76	5.19
2	.92	1.96	5.28
3	1.24	2.16	5.38
4	1.57	2.35	5.47
5	1.89	2.55	5.56
6	2.22	2.75	5.66
7	2.54	2.94	5.75
8	2.86	3.14	5.84
9	3.19	3.34	5.94
10	3.51	3.53	6.03
11	**3.83**	**3.73**	6.12
12	4.16	3.93	6.22
13	4.48	4.12	6.31
14	4.81	4.32	6.40
15	5.13	4.51	6.50
16	5.45	4.71	6.59
17	5.78	4.91	6.68
18	6.10	5.10	6.78
19	6.42	5.30	6.87
20	6.75	5.50	6.96
21	**7.07**	5.69	**7.05**
22	7.40	5.89	7.15
23	7.72	6.09	7.24
24	8.04	6.28	7.33
25	8.37	6.48	7.43
26	8.69	6.68	7.52
27	9.01	6.87	7.61
28	9.34	7.07	7.71
29	9.66	7.26	7.80
30	9.99	7.46	7.89
31	10.31	7.66	7.99
32	10.63	7.85	8.08
33	10.96	8.05	8.17
34	11.28	8.25	8.27
35	11.60	**8.44**	**8.36**
36	11.93	8.64	8.45
37	12.25	8.84	8.55
38	12.57	9.03	8.64
39	12.90	9.23	8.73
40	13.22	9.43	8.83

NOTE: "Crossover Points" are shown in bold type.

FIGURE 1

Estimated Cost of Circulation for Three Housing Alternatives

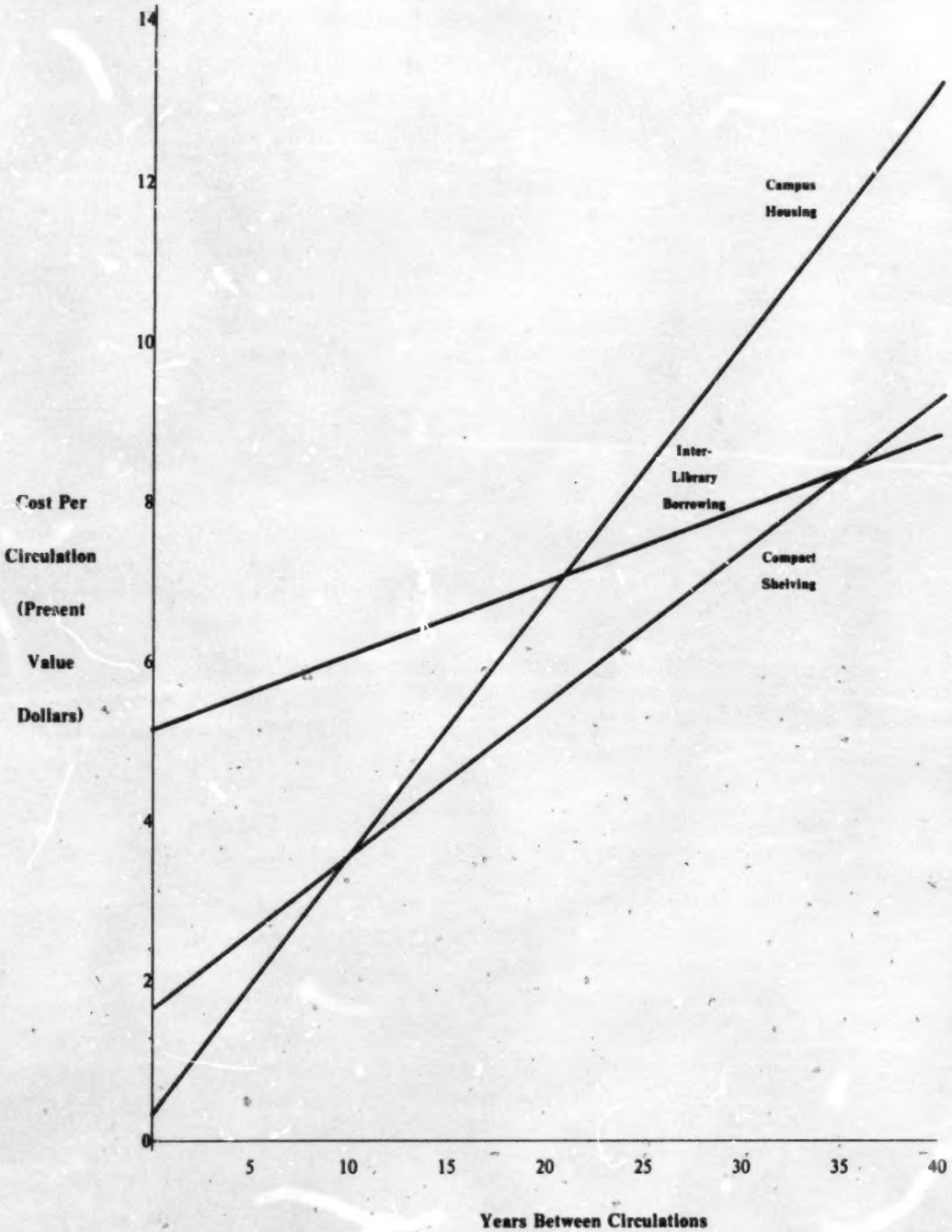

TABLE 3
Crossover Points for
Compact Shelving and Disposal

Disposition		Years Between
From	To	Uses (Y)
Campus	Disposal	20.93
Campus	Compact Shelving	10.17
Compact Shelving	Disposal	34.22

CONCLUDING COMMENTS

The crossover points presented in Table 3 represent our best estimates of empirical economic criteria for choosing housing options for library material based on expected frequency of circulation, applying available cost data. There is, of course, some question about the adequacy of the available data. Appendix C identifies the most uncertain cost elements, and explores the effects of some alternative assumptions about costs on the "crossover points" reported here. Since the equations are linear, this kind of sensitivity analysis can easily be performed without reliance on a computer.

We have reasonable confidence in advancing these crossover points and ranges as normative criteria for planning compact shelving facilities, especially because these criteria, unlike those developed by Palmour, explicitly recognize the costs imposed on library users by delays in the delivery of library material. However, we feel it necessary to highlight some of the "costs" which are not reflected in this analysis. Some of these represent merely technical problems and should not have significant effects on the crossover criteria. For instance, we cannot have accurate estimates of the cost of circulation from compact shelving until we have a period of experience with the operation of these compact shelving facilities to draw on. When books are disposed of, there is some cost for their physical disposal (as well as selection and record-changing costs) which may be partially offset by cash income (from sale of books) or "in-kind" income (in the form of materials received in exchange from other libraries). These factors are not reflected in the model, since relevant data do not appear to be readily available.

A more serious omission, noted in the introduction, relates to the assumption that a copy of a volume which is discarded will be available from another library when needed. In the absence of a national "last copy clearinghouse" which would assure availability of at least one copy of any publication, this assumption may be unwarranted. If we abandon the assumption, the cost of circulation for the disposal option must rise by some unknown factor to reflect costs imposed on users by the absolute unavailability of previously owned material. One solution to this problem might be to assume that books removed from the collection are sent to some national repository, like the Center for Research Libraries, which would assure their continued availability to the contributing library, and to other institutions, in perpetuity. Unfortunately, the nature of the budgeting process for the Center for Research Libraries makes an empirical estimate of the cost of this approach very difficult. For the time being, we must settle for a *caveat:* the real costs of disposal options are certainly indeterminately larger than the estimates provided herein; reliance on national institutions like the Center for Research Libraries is undoubtedly the best hedge against the risk that the cost of outright disposal will be unacceptably high, but the cost of this insurance policy is presently very difficult to estimate.

APPENDIX A

Modification of the Palmour Cost Model

The cost model developed by Palmour, et al.,[1] was designed to determine the total discounted cost, over a specified planning period, attributable to the ownership and use of a single periodical *title*. Thus, the Palmour model includes such features as the annual subscription price, annual staff costs related to check-in and claiming, mechanisms to estimate varying use rates for all the extant and future volumes of the title, the varying space requirements of the title over time, and other elements unique to the analysis of serial publications at the title level.

Most of these special features are irrelevant to the analysis of circulation costs for a single volume already held by the library, the situation which generally obtains when investigating a policy of moving individual volumes to a remote compact shelving facility using a selection rule based on frequency of circulation. Thus, the Palmour model has been modified to reflect these simplifying conditions.

The complete cost model used by Palmour was:

$$C = I_1 + (M_1 + P_1) \sum_{y=1}^{P} \theta^{y-1} + C_{v1} \sum_{y=1}^{P} a_y \theta^{y-1} + C_{w1} \sum_{y=1}^{P} w_y \theta^{y-1} \qquad \text{(A-1)}$$

$$+ C_{w1} \sum_{y=1}^{P} D_y^+ \theta^{y-1} + C_{b1} \sum_{y=1}^{P} D_y^- \theta^{y-1}$$

where:

C = present value of all costs associated with owning, using, weeding and/or borrowing the title.

I_1 = initial cost to acquire and catalog a new title.

M_1 = recurring annual cost: check-in, claiming, binding, etc.; this cost is assumed to be constant for all years in the planning period.

P_1 = annual subscription cost; assumed to be constant for all years.

y = the year index within the planning period, y = 1 to P.

P = the length of the planning period in years.

θ = the net discount rate, defined as $\theta = \frac{1+i}{1+r}$, where i is the inflation rate, and r is the discount rate, expressed as decimal fractions.

C_{v1} = cost of relegating an annual volume to remote compact shelving; assumed to be constant for all years in the planning period.

a_y = the number of annual volumes of the title held in the library in year y.

C_{w1} = the cost of weeding a single volume; assumed to be constant.

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1. Vernon E. Palmour, Marcia C. Bellassai and Robert R. V. Wiederkehr, *Costs of Owning, Borrowing, and Disposing of Periodical Publications*, Arlington, Virginia, Center for Naval Analyses, October 1977.

w_y = the number of volumes weeded in year y.

C_{u1} = the cost of satisfying a request for an annual volume held by the library.

D_y^+ = number of satisfied requests for an annual volume held by the library in year y.

C_{b1} = cost of satisfying a request for an annual volume not held by the library (interlibrary borrowing cost).

D_y^- = number of satisfied requests for annual volumes not held by the library in year y.

The derivation and justification of this formula are presented in Appendix A of the Palmour report.

In the present case, there are no initial cataloging costs, annual recurring costs, or subscription costs. Thus, the first two elements of the Palmour model reduce to zero. The remaining portion of the model, in Palmour's notation, is:

$$C = 0 + 0 + C_{v1} \sum_{y=1}^{P} a_y \theta^{y-1} + C_{w1} \sum_{y=1}^{P} w_y \theta^{y-1} + C_{u1} \sum_{y=1}^{P} D_y^+ \theta^{y-1} + C_{b1} \sum_{y=1}^{P} D_y^- \theta^{y-1} \qquad \text{(A-2)}$$

The first non-zero component of equation A-2 is related to the annual cost of housing the volumes of the title. Since, by definition, the parameter a_y (number of annual volumes held in year y) is always one in this application, the term reduces simply to $C_{v1} \sum \theta^{y-1}$.

The next component of A-2 is related to the cost of selecting a volume for relegation or weeding. In the present case a volume is either weeded or it is not, so this component can also be simplified. The expense incurred in selecting a single volume for relegation or weeding occurs only once: discounting is not necessary if we assume that the decision is made at the beginning of the planning period. Thus, the present value term ($\sum \theta^{y-1}$) can be eliminated. The term $w_y C_{w1}$ is zero if no selection process takes place (when volumes are retained on campus), and is equal to the selection cost per volume ($1 C_{w1}$) otherwise. Thence, we can further simplify this term by representing it as C_{w1}, the cost of selection, and assigning to it either the value zero or the estimated cost of selection, depending on the alternative under consideration. So far, then, the modified model is represented by:

$$C = C_{v1} \sum_{y=1}^{P} \theta^{y-1} + C_{w1} + C_{u1} \sum_{y=1}^{P} D_y^+ \theta^{y-1} + C_{b1} \sum_{y=1}^{P} D_y^- \theta^{y-1} \qquad \text{(A-3)}$$

The last two components of the model deal with the costs of use of a title. Two use-cost elements are required--internal use and interlibrary borrowing--in the Palmour model because, even if a serial subscription is cancelled, the library may incur internal costs for use of existing backfiles, as well as interlibrary borrowing costs for "future" volumes which are not purchased. For the single-volume analysis, this level of sophistication is unnecessary: again, the volume is either in the collection or it is not. Thus, one circulation-cost component is sufficient for the modified model.

The Palmour model is devised to accommodate differing circulation rates for the title as a whole in successive years, to reflect the simultaneous effects of growth of the backfile (the number of volumes being used) and declining circulation rates for older volumes ("obsolescence"). Again, this feature seems unnecessary for the single-volume case: the circulation rate of tht title is the circulation rate of the single volume. If the annual circulation rate of the volume is assumed to be constant over time, the rate-of-circulation parameter (D_y^+, D_y^-) can be moved outside the summation sign. The reduced version of the circulation-cost component, then, is $C_{u1} D \sum \theta^{y-1}$, where C_{u1} is the cost of a circulation for the alternative under consideration, and D is the average annual circulation rate. The reduced equation, in Palmour's notation, is now:

$$C = C_{v1} \sum_{y=1}^{P} \theta^{y-1} + C_{w1} + C_{u1} D \sum_{y=1}^{P} \theta^{y-1} \qquad \text{(A-4)}$$

The summation operation on theta, which appears in two components, is constant for any given values of P and θ. For convenience, we shall designate the value of $\sum \theta^{y-1}$ as r_t for a particular discount rate r, when P equals some value t, and denote this by designating the dependent variable as C_t. We can eliminate some unnecessary subscripts, and express the reduced model as:

$$C_t = C_v r_t + C_w + C_u D r_t \qquad \text{(A-5)}$$

The conversion of the total cost model (A-5) to a "cost per circulation" model is relatively straightforward, and the result has the desirable characteristic of linearity, which the total cost model does not. Since D is the average annual circulation rate, the total number of circulations over planning period t is simply Dt. The cost per circulation, by definition, is the total cost divided by the number of circulations, or $\frac{C_t}{Dt}$. Thus, to express the cost model in terms of cost per circulation, it is necessary only to divide through the model by Dt. The result is:

$$\frac{C_t}{Dt} = \frac{C_v r_t + C_w + C_u D r_t}{Dt}$$

$$= \frac{C_w + C_v r_t}{Dt} + \frac{C_u r_t}{t}$$

$$= \frac{C_u r_t}{t} + \frac{C_w + C_v r_t}{t} \frac{1}{D} \qquad \text{(A-6)}$$

Equation A-6, of course, is linear with respect to the factor $\frac{1}{D}$. The inverse of the circulation rate is simply the number of years between circulations, a variable which is more convenient to use and simpler to understand than the fractional annual circulation rate. Thus, we shall present findings in terms of cost per circulation, using the modified cost model:

$$U_t = \frac{C_u r_t}{t} + \frac{C_w + C_v r_t}{t} Y \qquad \text{(A-7)}$$

where:

U_t = The cost per circulation when capital costs are amortized over planning period t.

Y = the expected average number of years between circulations ($\frac{1}{D}$).

$r_t = \sum_{n=1}^{t-1} \frac{1}{1+r^n} = \frac{(1+r)^{t-1}-1}{r(1+r)^{t-1}}$ (by a standard formula), where r is the discount rate.

C_v = the annual cost of housing the volume.

C_w = the one-time cost to select the volume for weeding or some other special action.

C_u = the cost per circulation.

APPENDIX B

Procedure for Estimating the Cost of Delay

INTRODUCTION

It is difficult to estimate the costs imposed by delay in the delivery of library material, because these "costs" are borne by the library users and are largely intangible from the library's viewpoint, except in terms of complaints by users. One way to estimate these intangible costs is to ask users themselves how much they would be willing to pay to avoid delays of a particular length. To our knowledge, a study of precisely this sort has never been undertaken, but there exist two studies which, taken together, permit a very rough estimate of the average cost of delay; a 1972 study of the relative utility of timeliness in the delivery of library material,[1] and a 1975 study of users' willingness to pay for 48-hour interlibrary borrowing service.[2]

THE UTILITY OF TIMELINESS

The Reisman study applied a concept of relative value generally known as utility. If the absolute value of the timeliness of delivery of library materials cannot be precisely defined, it is nonetheless possible to establish a relative scale. For example, it would be hard to define the absolute value of one-day delivery, but most people would agree that two-day deliveries are, on the whole, less useful (have a lower utility) than one-day deliveries, and most people could provide an estimate of the reduced utility (e.g. a book delivered to me in two days is probably only half as useful to me as a book delivered in only one day).

Reisman used the Delphi technique to elicit from a group of 16 knowledgeable panelists (librarians, library administrators, academics and library trustees, representing all types of libraries) their judgements about the relative importance of timeliness for eleven delivery functions performed in a large cooperative library system. One of these functions was "intra-library loan," which we take to mean loans to library patrons. The panelists agreed that, if immediate delivery was taken to have a "utility" of one, four-day intra-library loan delivery had a "utility" of 0.5, and 12-day delivery had a utility of only 0.1.

Using Reisman's graphic presentation of utility as a function of delivery time for intra-library loans, we were able to fit a logarithmic curve to the data with an adequately high degree of fit ($R^2 = 0.97$). The resulting utility function was:

$$U = 0.89 - .23 \ln t \qquad \text{(B-1)}$$

where:

- U = cardinal utility (on a scale from 0 to 1).
- t = delivery time in days.
- $\ln t$ = the natural logarithm of t.

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1. A. Reisman, G. Kaminski, S. Srinivasan, J. Herling, and M. G. Fancher, "Timeliness of Library Materials Delivery: A Set of Priorities," *Socio-Economic Planning Sciences, 6,* pp. 145-152, 1972.
2. Donald D. Thompson, *Interlibrary Lending and Intercampus Photocopy: A Study of User Demand and System Response Among Northern University of California Campuses,* Special Projects, General Library, University of California, Berkeley, 25 June, 1975.

Figure B-1 is a graphic representation of the estimated utility function. As one would expect, utility declines most sharply for the lowest delivery times: a difference between immediate and one-day delivery is likely to be perceived qualitatively as much greater than the difference between thirteen- and fourteen-day delivery.

THE DOLLAR VALUE OF REDUCING DELIVERY TIME

A component of Thompson's study of interlibrary borrowing processes at the University of California, Berkeley, was a survey by Watson to determine whether users at four University of California campuses were willing to pay for guaranteed 48-hour delivery of their interlibrary borrowing (ILB) requests.[3] In this survey, users coming to the ILB department to request a book from another library were given a questionnaire in which they were asked to state (1) whether they would be willing to pay for guaranteed 2-day delivery, and (2) whether they were willing to pay at least a specified amount. Four amounts were specified--$2.50, $5, $7.50 and $10--on four different versions of the questionnaire, randomly distributed, so that each user was asked to respond to only one specific price level. The responses for University of California respondents are reproduced in Table B-1.

TABLE B-1
Willingness of Users of Interlibrary Loan Services
At Four University of California Campuses to Pay for
48-Hour Delivery of Requested Materials

Price Level	Total Responses	Willing to Pay at Least The Specified Price		Willing to Pay Less than The Specified Price		Not Willing to Pay	
$2.50	58	34	(58.62%)	6	(10.34%)	18	(31.03%)
$5.00	56	12	(21.43%)	10	(17.86%)	34	(60.71%)
$7.50	57	8	(14.04%)	20	(35.09%)	29	(50.88%)
$10.00	55	9	(16.36%)	21	(38.18%)	25	(45.45%)

NOTES: Users who responded both "not willing to pay" and "will pay the specified amount" (two responses) and those who offered an uncategorized response (six responses) are excluded.

Figures in parentheses represent the percentage of those asked about a specific dollar amount who responded in the manner indicated.

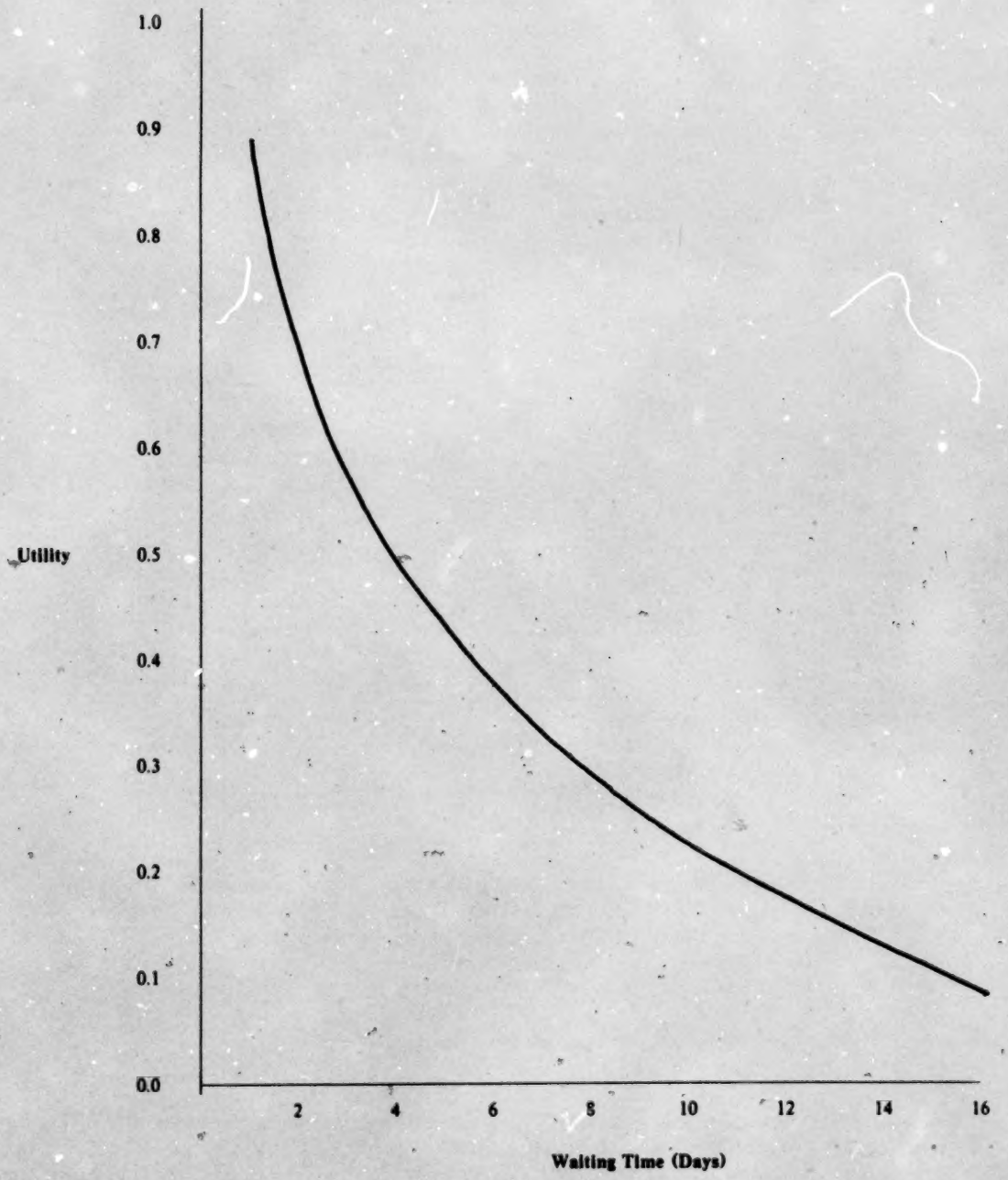
QUESTIONS: (1) "In general, would you be willing to pay extra for 48 hour service? (Yes/No)"; (2) "If yes, would you be willing to pay up to $xx.xx? (Yes/No)."

SOURCE: Adapted from Watson, "Result of User Survey...," p. 9.

3. Janie Watson, memorandum to Donald D. Thompson, "Result of User Survey, Interlibrary Lending Study," General Library, University of California, Berkeley, June 6, 1975.

FIGURE B-1

The Effect of Delivery Delays on the
Utility of Library Material



The arrangement of the Watson data is not ideally suited to estimate the continuous distribution of willingness to pay for 48-hour delivery, but with the adoption of certain assumptions it is possible to develop an estimate of the average price that respondents in the Watson study are willing to pay for fast delivery. First, we note that the mean (unweighted) proportion of users unwilling to pay for 2-day service, from Table B-1, is 47.02 per cent. Let us assume, then, that 47 per cent of ILB users are unwilling to pay for 2-day service. The remaining 53 per cent of users are assumed to be equally distributed among five price categories: \$0.01-2.49, \$2.50-4.99, \$5.00-7.49, \$7.50-9.99, and \$10.00+. Under this assumption, we can expect to find 10.6 per cent of respondents in each of the "willingness to pay categories."

TABLE B-2
Comparison of Expected and Actual Distributions of Responses to a "Willingness to Pay" Questionnaire

Specified Price Level	Willingness to Pay Specified Price	Expected Response (%)	Actual Response	
			%	N
\$2.50	Pay More	42.4	58.62	
	Pay Less	10.6	10.34	
	Not Pay	47.0	31.03	
	(Total)			58
\$5.00	Pay More	31.8	21.43	
	Pay Less	21.2	17.86	
	Not Pay	47.0	60.71	
	(Total)			56
\$7.50	Pay More	21.2	14.04	
	Pay Less	31.8	35.09	
	Not Pay	47.0	50.88	
	(Total)			57
\$10.00	Pay More	10.6	16.36	
	Pay Less	42.4	38.18	
	Not Pay	47.0	45.45	
	(Total)			55

NOTES: Expected values based on the hypothesis that: 47 per cent of the population is unwilling to pay; 10.6 per cent of the population is willing to pay a price within each of the following five categories: \$0.01-2.49, \$2.50-4.99, \$5.00-7.49, \$7.50-9.99, \$10.00+.

"Actual Response" values are from Table B-1.

Using these assumptions, we may "simulate" the statistical distribution of responses to the Watson questionnaire. If, for instance, we asked all users whether they were willing to pay at least \$2.50 for 48-hour service, we would find that 47 per cent would respond "not willing to pay," 10.6 per cent (in the \$0.01-2.49 category) would respond "willing to pay, but less than \$2.50," and the remainder, 42.4

per cent, would respond "willing to pay $2.50 or more." If a small random sample of respondents were asked this question, as was the case in the Watson survey, we would expect predictable random deviations from the "universal" distribution. In Table B-2, we show the expected percentage distributions of responses at Watson's four specific price levels, and the actual distributions recorded by Watson (from Table B-1). Given the number of actual responses at each price level, the percentage distribution of actual responses is not significantly different, in statistical terms, from the expected distribution, at the 95 per cent confidence level.

Proceeding further with this set of assumptions about the distribution of willingness to pay for 48-hour service, we can calculate the expected average value of 2-day delivery by multiplying the proportion of users in each price range by the mean value in that price range. The calculation is shown in detail in Table B-3. Thus, we estimate that the mean expected value of 2-day delivery, as measured by users' willingness to pay, is $3.31.

TABLE B-3
Estimate of Mean Willingness
To Pay for 48-Hour Delivery

Cell Range	Midpoint	Proportion Of Users	Mean Value
$0	$0	.470	$0
$0.01-2.49	$1.25	.106	$0.13
$2.50-4.99	$3.75	.106	$0.40
$5.00-7.49	$6.25	.106	$0.66
$7.50-9.99	$8.75	.106	$0.93
$10.00+	$11.25	.106	$1.19
Total		1.000	$3.31

NOTE: For purposes of this calculation, the "$10.00+" cell is assumed to have the same range as the other cells, i.e. $10.00-12.49, with a midpoint of $11.25. Since there are probably some users willing to pay more than $12.50, this assumption understates the average value of 48-hour delivery somewhat.

At the time the survey data were collected, the average time from request to delivery of material for the Berkeley campus was roughly 14 days, ranging from 11.2 days for final responses to requests for photocopies from northern UC campuses to 17.25 days for final responses to requests for loans of bound volumes from southern UC campuses.[4] No doubt, delivery times for requests to institutions outside of the University system were longer, but data for the specific time periods of the Thompson and Watson studies are not known to be available. We infer that users of the interlibrary borrowing service were willing, on the average, to pay $3.31 to reduce delivery time from 14 days to two days.

4. Thompson, *Interlibrary Lending...*, p. 6.

THE DOLLAR VALUE OF INCREASED UTILITY

It is now possible to combine the Reisman and Thompson/Watson findings to provide an estimate of the dollar value of increased utility, or conversely, the dollar cost imposed on users by the delivery delays arising from either remote compact shelving or reliance on interlibrary borrowing, as measured by users' willingness to pay to avoid such delays.

Our first step is to calculate an index of the dollar value of a change in utility. The utility function, Equation B-1, indicates that the cardinal utility of 2-day delivery is 0.75 (i.e. when $t = 2$, $U = 0.75$). The cardinal utility of 14-day delivery is 0.28. The change in utility caused by moving from 14-day delivery to 2-day delivery is the difference between the two cardinal utility levels, or 0.47. Thompson and Watson indicate that on the average, users are willing to pay $3.31 to bring about this improvement in their utility. Thus, the marginal dollar value of a change in utility as measured on Reisman's scale is $\$\frac{3.31}{.47}$, or $7.04.

If a volume is moved to regional compact shelving, delivery time may be reduced from "immediate" (utility = 1) to two days, the maximum response-time objective stated in *The University of California Libraries: A Plan for Development.* The change in utility is 0.25 (1.00 − 0.75), and its dollar value is .25 × $7.04, or $1.76, i.e. users would, on the average, be willing to pay $1.76 to avoid a delay of two days in receiving the materials they require ($2.12 in 1978 dollars).

If a volume is removed from the collection, the total loss of utility is 0.72, assuming that delivery time for interlibrary borrowing requests is 14 days (utility = 0.28). The delay cost of removal from the collection, then, is 0.72 × $7.04, or $5.07 ($6.12 in 1978 dollars).

APPENDIX C

Derivation of Cost Estimates and Sensitivity Analysis

In this appendix we first explain in more detail some of the cost parameters used in the body of the report and identify the estimates with the greatest uncertainty. We then present a sensitivity analysis with some alternate cost estimates. This provides a simple method for answering "what if ..." questions (e.g. "what if transportation turns out to be much more expensive?"), and gives a range within which actual crossover points may be expected to fall.

DERIVATION OF COST PARAMETERS

Campus Retention

The costs associated with retaining volumes in campus libraries are fairly well established. The only element we have had to estimate is the maintenance component of housing. Our assumption that this cost is comparable to that in a compact shelving facility is undoubtedly not completely accurate, but a small change in only one cost element is unlikely to alter the outcome by much. We thus take the campus retention costs as fixed at $C_v^c = \$1.09$, $C_w^c = \$0$, and $C_u^c = \$0.92$.

Relegation to Compact Shelving

Housing costs, including maintenance, have been thoroughly developed for compact shelving facilities. The *Plan for Development* also addresses questions of book selection, record changing and staffing costs. The only area where substantial uncertainty exists is in transportation--no specific plan for transportation of books and people between the campuses and the regional facilities has been advanced. Because transportation cost affects both the cost of selection for regional compact shelving (initial relocation of the physical volumes is included as a part of selection cost) and the cost of circulation, these two cost parameters will be examined more closely.

We look first at the selection cost, C_w^{cs}. Because the decision to house a volume in compact shelving facilities rather than campus libraries is a reversible one, the relatively low review cost of \$0.70 per volume (*Plan* p. 169) seems reasonable. If 90 percent of the volumes are actually selected, the resulting cost is \$0.78 per volume selected. There is no evidence to suggest that the record changing cost of \$1.00 per volume (*Plan* p. 175) is in error. In 1978 dollars these components total \$1.93.

To estimate transportation costs we first calculated a "weighted-average-volume-mile." The proportion of the total volumes in compact shelving facilities from each campus is calculated.[1] Each proportion is multiplied by the mileage from the campus to the nearest regional facility to obtain the average miles that a volume can be expected to travel, 7.25 miles (one way). If extremely cheap transportation can be found at \$0.01 per volume-mile, only \$0.07 will be added to the selection costs. If the cost should be as high as \$0.17, the travel allowance for University employees, \$1.23 will be added. On the assumption that these are extreme estimates, the text uses an intermediate cost of \$0.70 per volume for transportation and initial shelving. But in this section we attempt to isolate the effect of alternate costs, and use two figures for C_w^{cs}, a minimum of \$2.00 (\$1.93 + .07) and a maximum of \$3.16 (\$1.93 + 1.23).

The same lack of knowledge about transportation affects the circulation cost, C_u^{cs}. The direct staff cost is addressed in the *Plan for Development* (p. 177) and forms the basis for the estimate of \$1.66 per

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1. These calculations use relegation estimates made only for planning purposes. The actual number of volumes sent from each campus may differ from these estimates.

circulation in the text. There is no available alternate method for calculating the cost of delay, so we must add the same $2.12 used in the text, for a subtotal of $3.78. Although the system of transportation used for routine circulation will undoubtedly differ from that used for the initial transfer of volumes, the same maximum and minimum costs per volume mile, $0.17 and $0.01 respectively, can be used to establish the range in which the true cost can be expected to fall. This time, however, a round trip is involved, adding at least $0.15 per volume, and at most $2.47. Note that the text again uses an intermediate figure of $1.50 per circulation. The two values for C_u^{cs} needed for an analysis of the effects of transportation cost are a minimum of $3.93 ($3.78 + .15) and a maximum of $6.25 ($3.78 + 2.47).

Removal from the Collection

There is no uncertainty about the housing costs for these volumes--it is zero. We believe the higher cost for selection presented in the text is fully warranted for an irreversible decision, and again the record changing cost is the same. We hold C_w^w constant at $3.73 per volume.

The cost of interlibrary borrowing (ILB) is subject to some uncertainty. While Palmour's study[2] established an average internal borrowing cost (verification of bibliographic data, location of the item, preparation of requests, etc.) of $7.20 ($7.80 in current dollars), external costs were not investigated. Palmour used $0, $3, and $8 in his calculations, and the same figures converted to 1978 dollars are used here. The estimate in the text is based on the intermediate cost of $3; the others are used for the maximum and minimum analyses here. The only available estimate for the cost of the delay inherent in an ILB transaction, $6.12, is added in all cases. Therefore, C_u^w is at least $13.92 ($7.80 + 0 + 6.12) and at most $22.59 ($7.80 + 8.67 + 6.12).

Table C-1 summarizes the cost parameters which will be used to develop a range of crossover points in the following section.

TABLE C-1
Summary of Cost Estimates Used in Sensitivity Analysis

Location	C_v	C_w	C_u
Campus	$1.09	$0.00	$0.92
Compact Shelving			
Minimum	0.44	2.00	3.93
Maximum	0.44	3.16	6.25
Disposal and ILB			
Minimum	0.00	3.73	13.92
Maximum	0.00	3.73	22.59

SENSITIVITY ANALYSIS FOR TRANSPORTATION COSTS--CAMPUS TO COMPACT SHELVING

Using the general equation for the total cost per circulation, we can derive new equations for the maximum and minimum costs associated with compact shelving when transportation costs are allowed

2. Palmour, V., *Costs of Owning ... Periodical Publications*, p. 46.

to vary. The cost parameters are from Table C-1.

$$U^{cs} = \frac{11.88C_u^{cs}}{40} + \frac{C_w^{cs} + 11.88C_v^{cs}}{40} Y \qquad \text{(C-1)}$$

$$U_{min}^{cs} = \frac{(11.88)(3.93)}{40} + \frac{2.00 + (11.88)(.44)}{40} Y$$

$$U_{min}^{cs} = 1.1672 + .1807\ Y \qquad \text{(C-2)}$$

$$U_{max}^{cs} = \frac{(11.88)(6.25)}{40} + \frac{3.16 + (11.88)(.44)}{40} Y$$

$$U_{max}^{cs} = 1.8563 + .2097\ Y \qquad \text{(C-3)}$$

As derived in the text, the equation for the total cost per circulation for campus housing is:

$$U^c = .2732 + .3237\ Y \qquad \text{(C-4)}$$

To find the range of crossover points determined by the range of transportation costs, each U^{cs} equation is separately set equal to U^c and solved for Y. For example, setting the campus cost equation equal to the minimum compact shelving equation:

$$.2732 + .3237\ Y = 1.1672 + .1807\ Y$$

$$(.3237 - .1807)\ Y = 1.1672 - .2732$$

$$.1430\ Y = .8940 \qquad \text{(C-5)}$$

$$Y = 6.25 \textit{ years between circulations}$$

Similarly, equating U_{max}^{cs} with U^c results in Y=13.89 years between circulations. In other words, even if we have no firm estimates for transportation costs, assuming our other figures are correct, we can say that an economic criterion would send books to compact shelving facilities if they are used less often than once in 6.25 to 13.89 years (the former if transportation is "cheap," the latter if "expensive"). Thus even without complete cost data, we can see that a ten year relegation rule is a reasonable estimate.

A similar analysis can be performed on any cost for which some range of estimates can be made, for example, review costs for selection.

SENSITIVITY ANALYSIS WITH TWO VARYING COSTS

Adding the range of costs for circulation from interlibrary borrowing, C_u^w, to the above analysis, we must first calculate two new equations for U^w. Using the costs in Table C-1 in the general equation for the total cost per circulation, we get the following:

$$U_{min}^{w} = 4.1342 + .0933\ Y \qquad \text{(C-6)}$$

$$U_{max}^{w} = 6.7092 + .0933\ Y \qquad \text{(C-7)}$$

Each of these equations can be set equal to U^c to determine the effect on the crossover points for the case in which there is no compact shelving.

The range of years resulting from these calculations is presented in Table C-2, the "Campus to Disposal" option. However, if we wish to compare disposal with compact shelving we need to decide which expressions to equate, since there are two equations for each option. The choice depends on which underlying assumption is taken as the basis for comparison. For example, equating U^{cs}_{min} first with U^{w}_{min} and then with U^{w}_{max} to obtain a range of crossover points assumes that inexpensive transportation can be found and explores the effects of high and low external interlibrary borrowing costs. Here we present the calculations which result in the broadest range of crossover points. In other words, we set $U^{cs}_{min} = U^{w}_{max}$ and $U^{cs}_{max} = U^{w}_{min}$. The resulting ranges of crossover points are presented in Table C-2.

TABLE C-2
Ranges of Crossover Points from Sensitivity Analysis

Disposition		Range of Years
From	To	Between Uses (Y)
Campus	Disposal	16.76-27.93
Campus	Compact Shelving	6.25-13.89
Compact Shelving	Disposal	19.57-63.41

APPENDIX D

Discounting, Present Value and Inflation

The "Time Value" of Money

A major problem arises in any economic analysis in which costs are incurred over a period of years. The problem, quite simply, is that a dollar spent in the future does not have the same economic value as a dollar spent today. In general, if a particular sum of money *has* to be spent, anyone would prefer to spend it later rather than sooner.

Imagine that there is something that you must have four years from now. You will have to spend $100 to get it, but for some peculiar reason, there are two distinct ways to go about it. Either you can spend $100 *this year* to get "it" four years from now, or you can wait and spend $100 four years from now, and still get the same thing. Both choices have the identical outcome: i.e., "it," four years from now. The only difference between the choices is *when* you have to spend the money.

For convenience, we will call the first choice, $100 now, Project A. The second choice will be designated Project B. The table shows your cash outlays in both cases--either $100 now (Year Zero), or $100 four years from now (Year 4).

PROJECT	EXPENDITURE IN YEAR: 0	1	2	3	4	TOTAL EXPENDITURE
Project A	100	-	-	-	-	100
Project B	-	-	-	-	100	100

It seems intuitively obvious that, other things equal, you would prefer B. Why spend the $100 now, when you can wait, do other things with your money, and still get the same "it"? Economic analysis lends rigor to intuition in this case. You must spend $100 to get "it." If you spend $100 today, you will succeed (Project A). If, however, you put only $68.30 in a (hypothetical) bank which pays 10 per cent annual interest, compounded annually, you will have $100 (principal plus interest) at the end of four years. Withdraw your deposit and use it to pay for "it." Thus, your choice between A and B is really the choice of paying $100 now (A), or paying $68 now, which will equal $100 four years from now (B). An economist would say that the present value of B is $68.30: it only costs you $68.30 *today* to have "it" four years from now. However, you do not have an opportunity to invest your money in order to finance Project A; you must pay out $100 *immediately*. Therefore, the present value of Project A is $100. The table shows the present values of A and B.

PROJECT	EXPENDITURE IN YEAR: 0	1	2	3	4	TOTAL EXPENDITURE	EQUIVALENT INVESTMENT IN YEAR 0 (PRESENT VALUE)
Project A	100	-	-	-	-	100	100
Project B	-	-	-	-	100	100	68.30

Time Streams

More commonly, investment choices involve outlays over several years. As it happens, there is another way to purchase "it." You can pay in "installments," $20 now, and $20 each year for the next four years. We will call this option Project C.

PROJECT	EXPENDITURE IN YEAR: 0	1	2	3	4	TOTAL EXPENDITURE
Project A	100	-	-	-	-	100
Project B	-	-	-	-	100	100
Project C	20	20	20	20	20	100

Again, it appears intuitively obvious that Project C is preferable to Project A. "Spreading" the cost is more desirable than paying in a lump sum at the beginning. But is C better than B? The analytics of present value again provide the answer. If we wished to invest now in order to make the $20 payment in Year 1, we would need to invest only $18.18 at a 10 per cent interest rate. To make the $20 payment in Year 2, we must invest $16.53 today. Each of the annual payments in Project C has a present value associated with it. The present value of Project C, then, is simply the sum of the present values of each of the annual payments. The Present Value of Project C is $83.40; it is the total amount that you would have to invest *today* in order to lay out $20 per year through Year 4.

FUTURE PAYMENTS AND PRESENT INVESTMENTS FOR PROJECT C

Year	To Make This Payment In the Year Indicated	Invest This Amount Now
0	20	20
1	20	18.18
2	20	16.53
3	20	15.03
4	20	13.66
TOTAL	100	83.40

Comparing Time Streams

Imagine now that there are *two* ways to make installment payments: Project C at $20 per year, and Project D, which features a $60 down payment, and yearly payments of only $10. Both cost you $100 over the five-year period. Which is better? Intuition suggests that Project C is better, because the initial outlay is lower. Present value analysis confirms this choice.

We now introduce an offer you can't refuse: Project E, which is much like D, but requires a down payment of only *$55*, and annual payments of $10. The total undiscounted cost is only $95, $5 cheaper than any other project.

Surprisingly, though, a look at the present values of the projects indicates that we should *not* choose Project E, but stick with Project B, which has the lowest present value cost. Obviously, Project E comes out beter than D, but the high initial cost still makes it less preferable than either B or C. The underlying principle is the same: by avoiding a large expenditure *now*, we can save or invest our money, and be able to pay out later with some money left over.

PROJECT	EXPENDITURE IN YEAR: 0	1	2	3	4	TOTAL EXPENDITURE	EQUIVALENT INVESTMENT IN YEAR 0 (PRESENT VALUE)
Project A	100	-	-	-	-	100	100
Project B	-	-	-	-	100	100	68.30
Project C	20	20	20	20	20	100	83.40
Project D	60	10	10	10	10	100	91.70
Project E	55	10	10	10	10	95	86.70

Discounting and the Cost of Retention Analysis

An economist might claim that it is necessary to use discounting in the analysis of the cost of circulation simply because it is conceptually correct to do so. Library administrators might disagree, pointing out that they do not have the option of putting some of this year's revenue in the bank in order to finance future expenditures. However, discounting *is* conceptually correct, and an example may serve to indicate why it is necessary in the analysis of compact shelving and weeding choices.

Let us assume that we have to choose between keeping one book on campus or disposing of it and relying on interlibrary borrowing (ILB) to meet the demand for it. We further assume that the volume will be demanded once every four years. If we keep it on campus, we must "build a building" for it (i.e. account for its share of the cost of building and equipping a library to hold it), and pay the maintenance costs for keeping it available on the shelves. Let us assume that the building cost is $4 per volume, and maintenance costs are $1 per year. In Year 4, it is circulated, incurring an additional transaction cost of, say, $0.50.

	EXPENDITURE IN YEAR: 0	1	2	3	4	TOTAL EXPENDITURE
Campus	5.00	1.00	1.00	1.00	1.50	9.50
ILB	-	-	-	-	12.00	12.00

If we dispose of the volume instead, we incur neither building nor maintenance costs. In Year 4, however, we must incur whatever charges are involved in obtaining it by ILB. We will assume that the cost of ILB is $12.00. Using undiscounted costs, it appears that discarding and relying on ILB is more expensive, and the volume should be retained on campus. However, this conclusion fails to take into account the fact that, if ILB were chosen, there would have been a four-year period in which *no* expenditures were necessary to support the availability of this book.

PROJECT	EXPENDITURE IN YEAR: 0	1	2	3	4	TOTAL EXPENDITURE	EQUIVALENT INVESTMENT IN YEAR 0 (PRESENT VALUE)
Campus	5.00	1.00	1.00	1.00	1.50	9.50	8.51
ILB	-	-	-	-	12.00	12.00	8.20

The money not spent ($8.00) *could* have been used for other purposes: better public services, catching up on cataloging backlogs, even investing in an improved ILB system so that, four years later, the cost of ILB retrieval would in fact be less than $12.00. Higher budget authorities could have taken the "saved" money and invested it in new programs in the University, or in better housing or child care programs, or in employment development programs to promote economic growth. The latter options would have reduced the size of the library budget (albeit not much, since most of the cost of the

"Campus Option" is capital cost), but the library user in this case does not really care, as long as the book is available when it is needed.

Thus, there are real investment alternatives in the choice to retain or discard the book in question, and it is proper to use discounted values in making the decision. The result, in this example, is to show that the book should be discarded and obtained on ILB when needed. Because discounting is necessary in decisions to retain or discard, it must be applied in all cost comparisons to insure comparability of results.

Inflation and the Time Value of Money

The concept of the time value of money depends on two conditions: (1) the existence of a group of people who are willing to forego present consumption in return for larger sums of money in the future (i.e. "lenders"), and (2) a group of people who are willing to forego future consumption in order to obtain a sum of money in the present ("borrowers"). Without these two conditions, there would be no exchange of "present" and "future" money. When these conditions are present, institutions and money markets arise to facilitate the exchange of present and future money (e.g. banks, the Federal Reserve system, loan sharks and investment brokers).

Inflation represents the devaluation of currency, but not necessarily a reduction of real income. Prices rise, but incomes tend to rise with them (obvious failures in this adjustment mechanism result in recessions and depressions). Because inflation has the overall net effect of devaluating dollars rather than reducing real incomes, economists generally prefer to work with "constant" or "real" dollars, rather than with inflated, or "nominal" dollars.

This is not to say that inflation is not a genuine problem. Among other things, inflation adds considerably to the difficulty of keeping an economy in equilibrium, and raises doubts about the economic future that have serious effects on investment and consumption. Still, economists prefer to work with real dollars in cost analyses like the one we have proposed, since the use of constant dollars is more likely to reflect the real economic costs of the choices under consideration. Economists also know that there is something of an automatic adjustment for inflation built into the present value analysis. Lenders (investors or savers) have no incentive to lend if they cannot gain an adequate amount of "future money" as a result. If investors are unwilling to invest, the "money market" cannot sustain itself. Investors may become unwilling to invest if they sense that their returns will be eroded by the inflationary devaluation of future dollars. The money market responds by raising interest rates in order to maintain an adequate supply of investment money. Thus, the current interest or discount rate already reflects the effects of inflation on the "time value" of money. Adding an "inflation factor" to the analysis would be double-counting.